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Terpsicore: an Instructional Design Tool

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Abstract

The use of Instructional Design Theory in the construction of Learning Design can yield important benefits to learning resource designers. However, their use in Computer-Aided Design environments is conditioned to the existence of machine-readable representations of said theories. This work presents a tool that aids Learning Design construction by analyzing its conformance to an Instructional Design Theory. The analysis is then used as a basis for suggesting Learning Design improvements based on formal ontological representations of instructional design theories present in the tool's knowledge base. The software's functional architecture is described, and a case study is used to illustrate how this tool can be used to improve the conformance level of a Learning Design to the methods of a given Instructional Design Theory.

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"Keywords: Ontology, Instructional Design, E-learning;"

1. Introduction

The design of learning resources for e-learning environments is a complex endeavor. Instructional Design Theories (IDT) can support and guide a design, by giving the designer methods and guidelines that help them make practical decisions over resource constructions. Many of these theories, such as Learning By Doing (Schank, Berman, & Macpherson, 1999), Multiple Intelligences (Gardner, 1999), Instructional Transaction Theory (Merrill, 1996) and Elaboration Theory (Reigeluth, 1999), are expressed in natural language, as they are meant for instructional designers and not for computer systems. Having formal representations of these theories would be useful, so they can be used by instructional design computer support tools.

On the other hand, the IMS-LD specification (IMS, 2003) is a widely accepted solution to the problem of course specification. A Learning Design (LD) is the result of applying practical design guides such as an instructional design method to the specification of didactic sequences. However, a Learning Design is

the result of the design process, but does not describe the design method itself. (Vidal-Castro, Sicilia, & Prieto, 2012) propose formal ontological models representing methods of instructional design theories that can be used by systems to aid the building of learning resources.

This work presents a tool that uses formal representations of Instructional Design theories to aid designers in the construction of Learning Designs by analyzing the LDs and then generating suggestions based on these instructional theories. The rest of the work is structured as follows: Section 2 presents the fundamentals of IDT representations which are the tool's knowledge base. Section 3 describes the software tool's most important features. Section 4 presents an LD improvement case study that showcases the tool's usefulness. Finally, we present conclusions and future development lines.

2. Modeling Instructional Design theories

Vidal-Castro et al., 2012 describe an elicitation process through which the guides and methods of Instructional Design theories were modeled using an ontological language, using their descriptions in natural language as a starting point. An ontology representing the IMS-LD specification (Amorim, Lama, Sánchez, Riera, & Vila, 2006) and written in the OWL language (W3C, 2004a) was used for modeling. IDT methods were added to the ontology, by representing them using SWRL language rules (W3C, 2004b) as constraints on ontology. These representations conform the so-called Instructional Design Theories Catalogue (Vidal-Castro et al., 2012). The importance of this proposal lies in its proposition of a general model for the formal representation of Instructional Design theories.

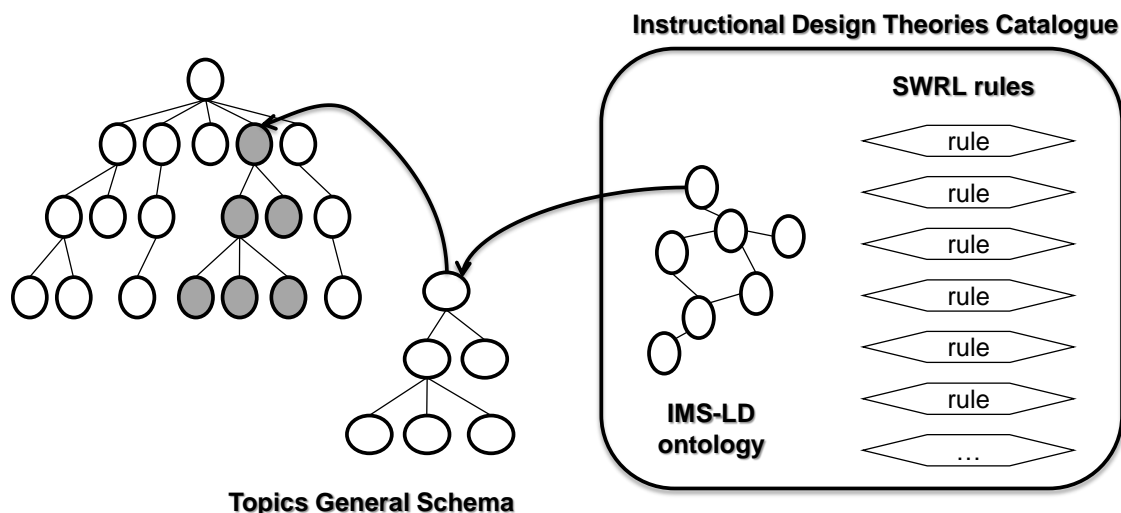


Figure 1: Relationship between the IDT Catalogue to other ontological structures

The general model of IDT representation considers other ontological structures besides the previously mentioned ontology. Some IDTs require a hierarchical topic organization. For example, Elaboration Theory requires a broader identification of learning topics, and its organization can be obtained from domain ontologies. Additionally, learning topics or contents can be related to learning outcomes by means of a Topics General Schema (TGS). The relationship between these structures and the IDT Catalogue is represented in Figure 1.

All ontological structures used in modeling are identified by a namespace (For example, TGS, UOL, LOM, among others) that are used in the Catalogue's SWRL rules. For example, Learning by Doing theory provides the method stating "Must allow enough opportunities to practice the skill and seek the knowledge". This method's guideline is represented by the following rule:

```

uol:Learning-Object(?lo) ^
uol:Metadata (?m) ^
uol:metadata-ref(?lo,?m) ^
lom:LOM (?lom) ^
uol:metadata-description(?m,?lom) ^
lom:Educational(?edu) ^ lom:educational-ref(?lom,?edu) ^
lom:learningresourcetype(?lo, "exer")
→ practiceSkill(?lo, "true")

```

In this rule, we can recognize elements from an ontology representing a Unit of Learning (UOL) and from an ontology representing the IEEE LOM standard (LTSC, 2002). Specifically, this rule checks that the Learning Design use Learning Objects (LO) that are oriented toward practical skills. The `learningresourcetype` metadata from the LOM standard describes the type of resource, whereas "exercise" is an example of a resource describing an LO oriented toward practical skills. A complete list of the rules composing the IDT Catalogue modeled in (Vidal-Castro et al., 2012) is stored in a wiki located at http://www.ieru.org/idont-wiki/index.php?title=Main_Page

3. Terpsicore, a support tool for learning design construction

The IDT Catalogue may be used by several applications to support Instructional Design activities. One of them is to validate the conformance of an LD to a certain IDT. This means that, by using the IDT Catalogue as a knowledge base, it is possible to determine if the LD built by a designer complies with the guidelines and suggestions described by a given theory's methods. This section presents the main aspects to be considered in the implementation of a LD conformance analyzer with respect to a TDI.

Terpsicore was built so as to be able to use the IDT Catalogue in a real-world LD construction. Terpsicore is an application that integrates into ReCourse, a popular LD editor well-known in the e-learning community (Beauvoir, Griffiths, & Sharples, 2009). Terpsicore allows designers to validate an LD for conformance to IDT in an integrated manner and using a well-known environment. Figure 2 shows the prototype's functional architecture, illustrating the application's interaction with the IDT Catalogue and the ReCourse editor.

From a functional point of view, Terpsicore is divided in 3 principal components. These components are:

- Instance creation. It creates instances representing the LD in the IMS-LD ontology using the `imsmanifest.xml` file generated by an LD editor compatible with the IMS-LD specification (IMS, 2003).
- Rule-based inference. This module executes the Catalogue's rules. Its outputs are "true" or "false" values assigned to the Learning Design properties, representing their conformance or non-conformance to the IDT's methods.
- Results display. This process generates a XML file containing conformance results for every rule and also outputs LD improvement suggestions so as to have it conform to the theory's method guidelines.

The designer uses the application as an added feature to the ReCourse editor. Figure 3 presents a view of the application's main screen integrated to the ReCourse editor, showing all steps to be followed when validating a LD.

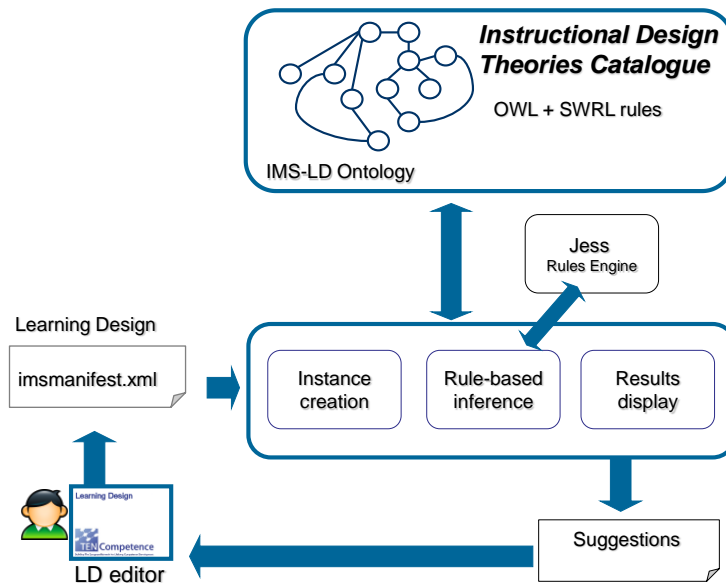


Figure 2: Functional prototype architecture

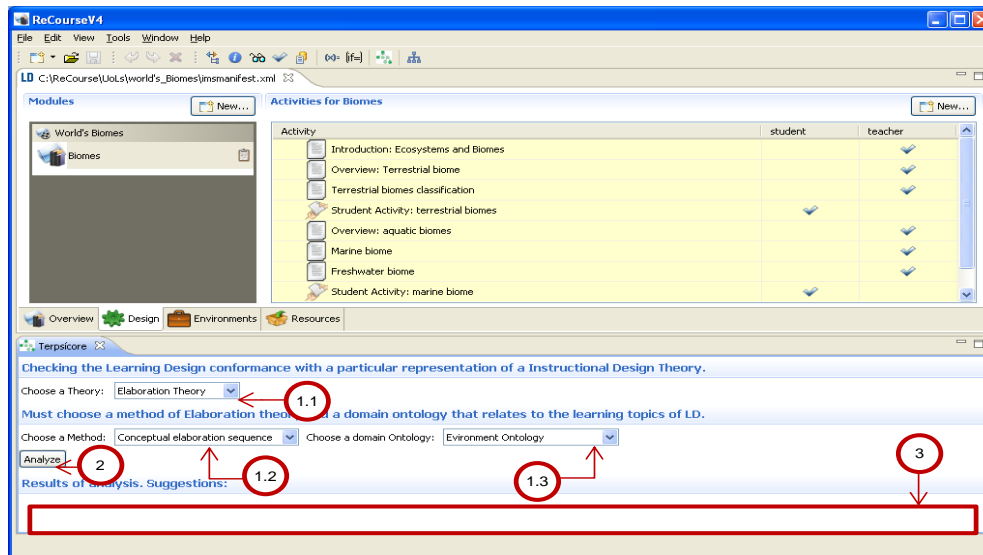


Figure 3: Terpscore integration to the ReCourse editor environment

1. When starting a session, the user must select:
 - 1.1. The Instructional Design theory to apply to the LD analysis. For example, Elaboration Theory (Reigeluth, 1999).
 - 1.2. Any of the theory's submethods. In the case of Elaboration Theory, analysis may be done by three submethods: Conceptual elaboration sequence, Theoretical elaboration sequence y Simplifying conditions sequence.
 - 1.3. The domain ontology from which to extract learning topics, as demanded by Elaboration theory.
2. LD validation is performed.
3. Validation results indicate which rules are not satisfied in the LD, and LD improvement suggestions.

4. A case study

The following case study explores the applicability of ontological representations of Elaboration Theory methods (Reigeluth, 1999) and also Terpsicore's suitability and usefulness. Using an initial LD as a starting point, we show the process of analyzing its conformance to Elaboration Theory, specifically to the conceptual elaboration sequence submethod . Then, a new improved LD may be built by following the application's results and suggestions.

The case study considers the construction of an LD for an environmental science course related to the “Biomes of the World: terrestrial and aquatic” topic. Learning objectives are related to biomes' general features and to aquatic and terrestrial biome classification. The topics to be covered by the LD are based on the Environment Ontology (EnvO^{*}), a domain ontology developed with the support of the Genomic Standards Consortium.

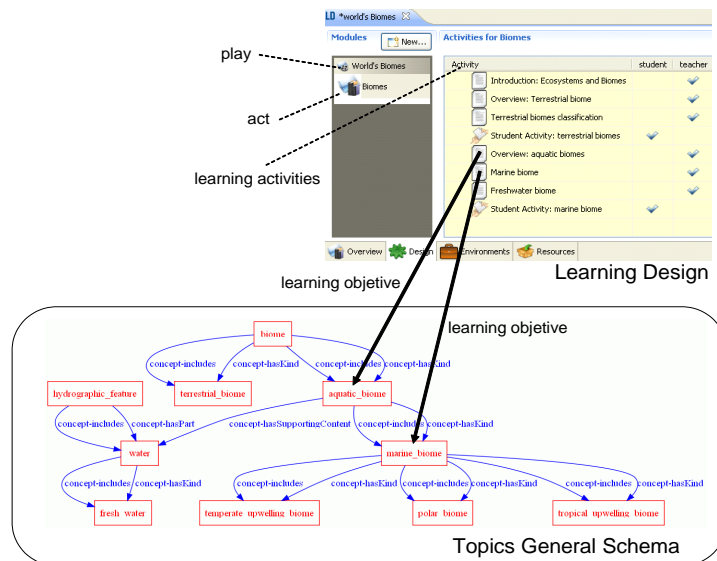


Figure 4: Learning Design fragment y relationship between learning activities and topics in the Topics General Schema.

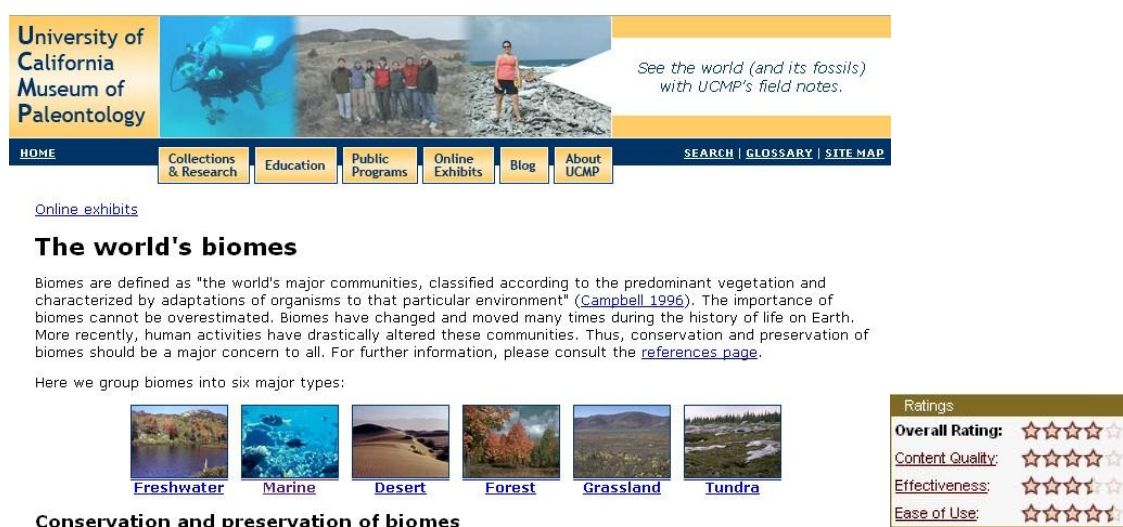
^{*} <http://environmentontology.org/>

Learning design topic selection was done using topic sequencing proposed by Elaboration theory. Thus, the LD considers topics such as terrestrial, aquatic, polar, and tropical coral biome classification systems, among others. These concepts become a part of the TGS structure, which registers learning topics keeping the *is_a* and *part_of* ontological relationships that are present in the EnvO ontology. Supporting content topics (Reigeluth, 1999) are also included in these structures: for example, the habitat topic is a supporting content for biome and water is a supporting content for aquatic biome. Figure 4 presents a view of the initial LD, where TGS instances representing topics and supporting contents are shown in its lower half.

This Learning Design was built using the ReCourse tool. Structurally, it consists of a “World’s Biomes” play, including a “Biomes” act. The act includes 8 learning activities to be performed by the students and an instructor, if needed (see Figure 4).

This Learning Design also uses LOs related to marine and terrestrial biomes retrieved from the MERLOT repository. For example, the “Biomes of the World” LO is used in the “Overview: Terrestrial Biomes” learning activity

The analysis of LD conformance to Elaboration theory methods requires linking learning activities to learning topics. This is done through the ontology’s *tgs:concept-learning-objective*, which relates activities to TGS topics. As an example, Figure 5 shows that the “overview: aquatic biome” is related to the aquatic biome topic, and that the “marine biome” activity is related to the marine biome topic. Using Terpsicore, users can establish relationships between learning activities and learning topics. Terpsicore instances the information representing the LD and registers the relationships between learning activities and learning topics entered by the designer. Rule-based inference is then performed, executing those rules corresponding to the Conceptual Elaboration Sequence method representation.



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The world's biomes

Biomes are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment" (Campbell 1996). The importance of biomes cannot be overestimated. Biomes have changed and moved many times during the history of life on Earth. More recently, human activities have drastically altered these communities. Thus, conservation and preservation of biomes should be a major concern to all. For further information, please consult the [references page](#).

Here we group biomes into six major types:

					
Freshwater	Marine	Desert	Forest	Grassland	Tundra

Conservation and preservation of biomes

Ratings	
Overall Rating:	☆☆☆☆☆
Content Quality:	☆☆☆☆☆
Effectiveness:	☆☆☆☆☆
Ease of Use:	☆☆☆☆☆

Figure 5: Learning Object used in initial LD construction. This resource was retrieved from MERLOT repository (<http://www.merlot.org>).

Figure 6 shows the results presentation screen, illustrating analysis results along with conformance suggestions. Conformance suggestions generated by the validation software correspond to rules that are not satisfied by the Learning Design. To illustrate this, the source of the first recommendation is explained, along with LD improvement actions.

Figure 6: Results of LD conformance analysis to the Conceptual Elaboration Sequence submethod.

The “Learning activities associated with broader concepts should be presented first” recommendation is generated because certain rules are not being followed. These rules model the method guideline stating that broader concepts must be presented first:

```
(Regla 1)
ld:Learning-Activity(?a1) ^
ld:Learning-Activity(?a2) ^
differentFrom(?a1, ?a2) ^ ld:Activity-Structure(?as1) ^
ld:execution-order(?a1, ?o1) ^
ld:execution-order(?a2, ?o2) ^
ld:execution-entity-ref(?as1, ?a1) ^
ld:execution-entity-ref(?as1, ?a2) ^
swrlb:lessThan(?o1, ?o2) → rr:showsBefore(?a2, ?a1)

(Regla 2)
rr:showsBefore(?a1, ?a2) ^
ld:ConceptLearningActivity(?a1) ^
ld:ConceptLearningActivity(?a2) ^
differentFrom(?a1, ?a2) ^ ld:Activity-Structure(?as) ^
ld:execution-entity-ref(?as, ?a1) ^
ld:execution-entity-ref(?as, ?a2) ^
tgs:concept-learning-objective(?a1, ?c1) ^
tgs:concept-learning-objective(?a2, ?c2) ^
tgs:KnowledgeItem(?c1) ^ tgs:KnowledgeItem(?c2) ^
tgs:concept-includes(?c2, ?c1) ^
differentFrom(?c1, ?c2) → rr:broaderFirst(?as, "true")
```

Rule 1 determines the execution order of two learning activities that are grouped in an activity structure, and whose order of execution is defined via a `ld:execution-order` property. Rule 2 verifies that this execution order corresponds to the topic’s breadth, which in turn is related to the TGS depth of the topic pointed to via the `concept-learning-objective` relationship. In this case, the initial LD does not have either an activity structure or a defined activity execution order. In order to satisfy these rules, an activity structure and an activity execution order must then be defined.

Finally, the realization of all proposed modifications leads to an improved LD. Figure 7 presents a partial view of the improved LD in which the creation of new acts and activity structures and conformance analysis results generated by Terpsicore can be seen. The lower half of the figure shows no further suggestions. Consequently, this LD conforms to all rules that partially represent the Conceptual elaboration sequence of Elaboration Theory.

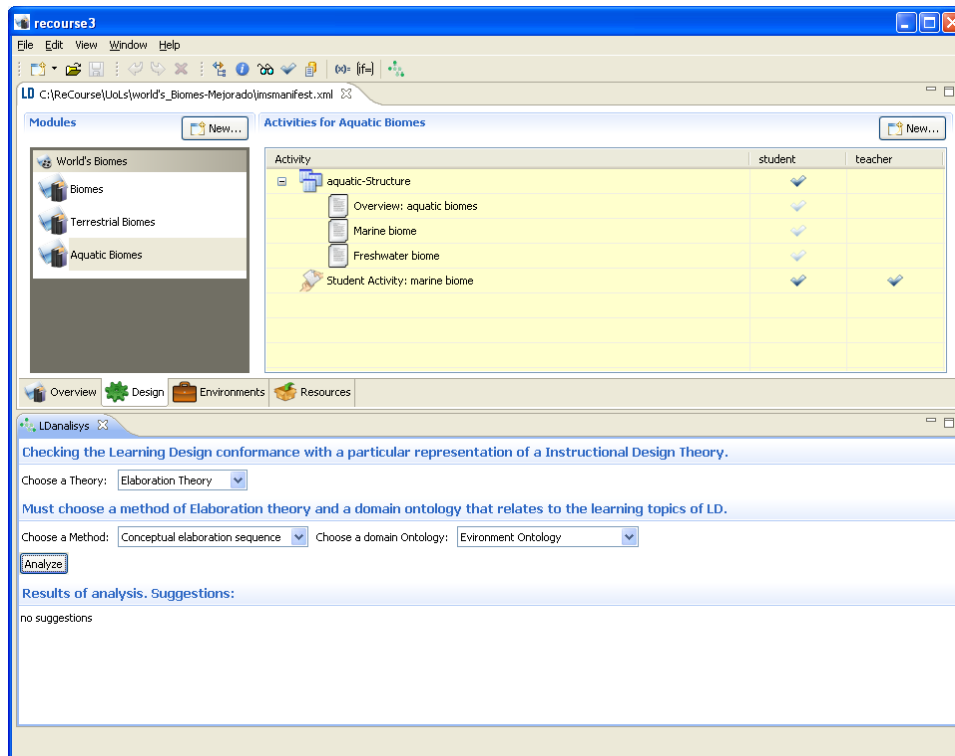


Figure 7: Improved LD analysis results.

5. Conclusion

The benefits of using Instructional Design theory to LD construction are obvious, as they help guide the design of resources to aid student learning. However, the fact that most IDTs are expressed in natural language hampers their use in Computer-Aided Design environments.

This work presented the Terpsicore tool which integrates into the ReCourse LD editor environment. This tool allows analyzing LD conformance to an IDT's methods and generates as a result a list of suggestions for improving LD conformance, which are based on the formal ontological representation of those IDTs that make up the tool's knowledge base.

The usefulness of this tool was shown via a case study, the improvement of an LD in the environmental sciences domain, specifically "World biomes".

The Terpsicore application is in its first version and, while it meets its design goals, there is fertile ground for improvement. The application code and associated documentation can be downloaded from <http://code.google.com/p/terpsicore/>.

Work is currently underway on incorporating Fuzzy Logic to the modeling stage and on improving the tool through its evaluation by users and experts.

Acknowledgements

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References

- Amorim, R., Lama, M., Sánchez, E., Riera, A., & Vila, X. (2006). A Learning Design Ontology based on the IMS Specification. *Educational Technology & Society*, 9(1), 38-57.
- Beauvoir, P., Griffiths, D., & Sharples, P. (2009). Learning Design Authoring Tools in the TENCompetence Project . In R. Koper (Ed.), *Learning Network Services for Professional Development* (pp. 379-387). Springer Berlin Heidelberg.
- Gardner, H. (1999). Multiple approaches to Understanding. In C. Reigeluth (Ed.), *Instructional-Design Theories and Models. A New paradigm of Instructional Theory. Volume II*. Lawrence Erlbaum Assoc.
- IMS. (2003). Learning Design (IMS-LD), Specification V1.0. IMS Global Learning Consortium. Retrieved from <http://www.imsglobal.org/learningdesign/index.html>, en Diciembre de 2008.
- LTSC. (2002). IEEE Learning Object Metadata (LOM), Draft Standard IEEE1484.12.1. IEEE Learning Technology Standards Committee. Retrieved from http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf
- Merrill, M. (1996). Instructional Transaction Theory: An Instructional Design Model based on Knowledge Objects. *Educational Technology*, 1996, 36(3) pp 30-37.
- Reigeluth, C. M. (1999). *Instructional-Design Theories and Models, Volume II: A New Paradigm of Instructional Theory*. Mahwah, NJ: Lawrence Erlbaum Assoc.
- Schank, R., Berman, T., & Macpherson, K. (1999). Learning by Doing. In C. Reigeluth (Ed.), *Instructional-Design Theories and Models. A New paradigm of Instructional Theory. Volume II*. . Lawrence Erlbaum Assoc.
- Vidal-Castro, C., Sicilia, M.-A., & Prieto, M. (2012). Representing instructional design methods using ontologies and rules. *Knowledge-Based Systems (In Press)*, (0), -. doi:10.1016/j.knosys.2012.04.005
- W3C. (2004a). OWL Web Ontology Language Reference. World Wide Web Consortium. Retrieved from <http://www.w3.org/TR/2004/REC-owl-features-20040210/>
- W3C. (2004b). SWRL: A Semantic Web Rule Language Combining OWL and RuleML. World Wide Web Consortium. Retrieved from <http://www.w3.org/Submission/2004/SUBM-SWRL-20040521/>